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THE IMPACT OF BODY-PART-NAMING TRAINING ON THE ACCURACY OF IMITATIVE PERFORMANCES IN 2- TO 3-YEAR-OLD CHILDREN

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A series of three experiments explored the relationship between 3-year-old children's ability to name target body parts and their untrained matching of target hand-to-body touches. Nine participants, 3 per experiment, were presented with repeated generalized imitation tests in a multiple-baseline procedure, interspersed with step-by-step training that enabled them to (i) tact the target locations on their own and the experimenter's bodies or (ii) respond accurately as listeners to the experimenter's tacts of the target locations. Prompts for on-task naming of target body parts were also provided later in the procedure. In Experiment 1, only tact training followed by listener probes were conducted; in Experiment 2, tacting was trained first and listener behavior second, whereas in Experiment 3 listener training preceded tact training. Both tact and listener training resulted in emergence of naming together with significant and large improvements in the children's matching performances; this was true for each child and across most target gestures. The present series of experiments provides evidence that naming —the most basic form of self-instructional behavior—may be one means of establishing untrained matching as measured in generalized imitation tests. This demonstration has a bearing on our interpretation of imitation reported in the behavior analytic, cognitive developmental, and comparative literature.

Key words: naming, imitation, listener behavior training, tact training, matching training, young children, manual gestures

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Researchers of different theoretical persuasions agree that imitation is a key driver of development in infancy and childhood, and that its determinants deserve careful experimental investigation. Behavior analysts distinguish between a directly trained repertoire of matching relations, established through discriminative reinforcement like any other operants (Skinner, 1953, pp. 119–120), and generalized imitation, a repertoire of emergent matching relations (Catania, 1998, p. 228). This latter kind of imitative repertoire, which could enable young children to learn new behaviors quickly and without the need for direct training, has been the focus of numerous experiments (e.g., Baer & Deguchi, 1985; Baer & Sherman, 1964; Erjavec, Lovett, & Horne, 2009; Horne & Erjavec, 2007; Kymissis & Poulson, 1994; Poulson & Kymmissis, 1988; Poulson, Kyparissos, Andreatos, Kymissis, & Parnes, 2002; Poulson, Kymissis, Reeve, Andreatos, & Reeve, 1991; Steinman, 1970; Waxler & Yarrow, 1970). Traditionally, the methodology for examining generalized imitation consists of the presentation of discrete trials on each of which the child observes a different modeled action to which he or she is asked to respond. Following some modeled actions, correct matching responses result in the delivery of reinforcers, but matching responses to the remaining models are not reinforced. It is the children's responses to the latter models that are of interest, as matching of unreinforced probes is considered to provide evidence of generalized imitation. If unreinforced matching is shown to be sensitive to changes in the contingencies provided for reinforced responses, this is considered to be evidence that generalized imitation had been established as a higher-order class of behavior (Catania, 1998). Thus, evidence of generalized imitation has been reported in infants (e.g., Poulson et al., 1991, 2002), normally developing children (e.g., Baer & Sherman, 1964; Catania, 1998; Sherman, Clark, & Kelly, 1977), and children from special populations (e.g., Baer,

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Peterson, & Sherman, 1967; Garcia, Baer, & Firestone, 1971; Peterson, 1968).

In the recent literature, additional necessary controls have been identified and incorporated into tests for generalized imitation. First, it has been shown that all such tests ought to employ pretests for novelty of the target actions presented as unreinforced probes. Second, researchers also need to ensure that parents and other caregivers remain unaware of the experimental procedures, particularly the modeled target behaviors, for the duration of the study. These steps safeguard against false positives—cases where target responses may be extraexperimentally established as trained matching relations either prior to or during the experiment (see Erjavec & Horne, 2008; Erjavec et al., 2009; Horne & Erjavec, 2007 for a more detailed discussion of these points and relevant data). Third, in tasks that model an action directed at a particular object, it has been shown that the action component may not be necessary to evoke the target response (see Zentall, 2006). For example, Horne, Erjavec, and Lovett (2009) tested infants' imitation of a particular target behavior. Depending on assigned condition, the infants were either shown a mitten falling from a puppet's arm (affordance demonstration control), or an experimenter pointing to a mitten on the puppet's arm (social enhancement control), or an experimenter removing the mitten from the puppet's arm (target behavior modelling condition). This study demonstrated that infants in the affordance and social enhancement control conditions produced as many mitten removals in subsequent test trials as those who had seen the full target behavior of the experimenter removing the mitten. Because object affordances and social enhancement are potential confounding sources of control when target behaviors are actions on objects, the authors concluded that, to provide a strong test of generalized imitation, future studies should employ novel, empty-handed gestures (i.e., those that do not involve touching or holding objects) as target behaviors (see Horne & Erjavec, 2007, for further discussion of this issue and relevant data).

Recent studies examining the determinants of imitation in infants and young children that have employed these experimental controls have failed to replicate the results of earlier studies. For example, neither extensive exposure to modeling nor multiple-exemplar matching training led to the emergence of novel untrained matching relations in infants (Erjavec et al., 2009; Horne & Erjavec, 2007). These results indicate that the imitative abilities of infants and young children may have been overestimated in the earlier behavior analytic literature, and for similar reasons, also in cognitive-developmental studies (e.g., see Hurley & Chater, 2005). Clearly, more research is needed to identify the conditions under which young children may show emergent matching of novel behaviors.

One possibility is that children's growing verbal repertoires may alter the way in which they respond to behaviors modeled by others. Although experimenter-generated instructions have long been identified as one determinant of matching responses in school- and nursery-age children (see Baer & Deguchi, 1985, for a review), the effects of self-instructions on young children's imitative responses have not yet been examined directly. Horne and Lowe (1996, 1997; also see Lowe & Horne, 1996) propose that learning to name objects and events in their environment fundamentally changes the way in which children behave. They define naming as a higher-order bidirectional relation, in which the speaker responds as a conventional listener to his or her own verbal responses. Via this intraindividual speaker–listener relation, when a child sees an object (e.g., a shoe) and tacts it (''shoe''), the child next responds as a listener to that tact by looking once again at the object, and so on. Naming is therefore the earliest form of self-instruction: This circular speaker–listener relation enables the child to maintain his or her attention on a particular object for as long as that particular cycle of speaking and listening continues. In addition, whenever the child names a particular object (e.g., the child's shoe), the listener response includes looking at other objects that he or she has learned to call by the same name. Naming is therefore an important means of establishing category relations between objects (e.g., the child's shoe and the wide variety of adult's shoes). Indeed, common naming (but not common listener behavior) has been shown to establish untrained categories in young children, even between objects that have no features in common (see Horne, Hughes, & Lowe, 2006; Horne, Lowe, & Harris, 2007; Horne, Lowe, & Randle, 2004; Lowe, Horne, &

Hughes, 2005; Lowe, Horne, Harris, & Randle, 2002). Therefore, it is possible that when a child observes her mother touching her own foot, the child may tact what her mother has done by saying ''touch foot'' or simply ''foot'' and then respond in turn as a listener to that utterance by looking at her own foot and touching it. In this way, the self-instructional effects embodied in the name relation may alter the way in which a child (or adult) responds on generalized imitation tests. Some recent findings suggest that this is indeed the case. For example, many empty-handed gestures used as target behaviors in imitation tests involve touching a specific body part—a shoulder, an elbow, a palm, a foot, and so on. It is well documented that infants and young children accurately match some of these models, but respond incorrectly to the remaining models by touching a different part of their own body, or using an incorrect movement (e.g., Bekkering & Wohlschlager, 2002; Bekkering, Wohlschlager, & Gattis, 2000; Erjavec et al., 2009; Gleissner, Meltzoff, & Bekkering, 2000; Horne & Erjavec, 2007). Erjavec and Horne (2008) have demonstrated that toddlers' responses to hand-to-body target gestures tend to be more accurate for those actions that frequently feature in naming and matching games that the children play with their caregivers (e.g., the nursery rhyme ''Heads, shoulders, knees and toes'') than for comparable actions that had no such training history (also see Camões-Costa, Erjavec & Horne, 2010). However, the separate contributions of matching training, naming training, and listener training have not yet been assessed directly.

Let us consider in more detail how learning to name a target body part may change a child's performance in an imitation test. Figure 1 (left panel) illustrates the naming relation for *foot* (adapted from Horne & Lowe, 1996, p. 201). A child, who has learned to name this part of the body, sees her foot, and then says ''foot''. This response automatically generates the auditory stimulus /foot/ to which the child responds as a listener by looking once again at her foot. This name relation can be evoked by seeing a foot or hearing /foot/; therefore, it can be re-evoked each time the foot is seen, or through self-echoing. As caregivers train this relation, they are likely to point not only to the child's foot but also to other feet—their own and siblings' feet, feet on toys, pet animals, birds, and so on. This name relation will therefore come to include a variety of other stimuli that a child may name and, in so doing, categorize them as feet (this relation may also include a variety of conventional listener responses—looking at, pointing to, touching, kicking, putting on and pulling off socks or shoes, and so on, depending on the child's learning history). When, in an imitation context, the child sees an experimenter modeling a foot-touch, she may name the target body part as ''foot'', overtly or covertly, and respond to her own utterance by orienting to and touching her own foot (see Figure 1, right panel). This could happen even if the child has never been directly trained to produce a matching response to a model of a hand-to-foot target action. Thus an emergent matching response may be emitted in a generalized imitation test. However, if the child has not yet learned to name the target body part touched during a modeling demonstration, then naming cannot facilitate matching of the target behavior.

In the present study, we employed multiple baseline designs in three experiments to explore the relationship between young children's ability to name target body parts and their untrained matching of target hand-to-body touches. Participants were presented with repeated generalized imitation tests in which models of four trained (baseline) hand-to-body touches were interspersed with four unreinforced (target) body touches; the novelty of all target behaviors was established at the outset for each individual child. The separate effects of training the children to (i) tact the target locations, and (ii) respond as listeners to the experimenter's tacts of the target locations on their subsequent matching of the target body touches, were next investigated. We also examined whether prompts for on-task naming of target body parts enhanced the children's generalized matching performances.

This research complied with British Psychological Society guidelines for research with children and was approved by the School of Psychology Ethics Committee.

EXPERIMENT 1

Method

Participants

Three typically developing girls who attended the University Nursery and Childcare Centre

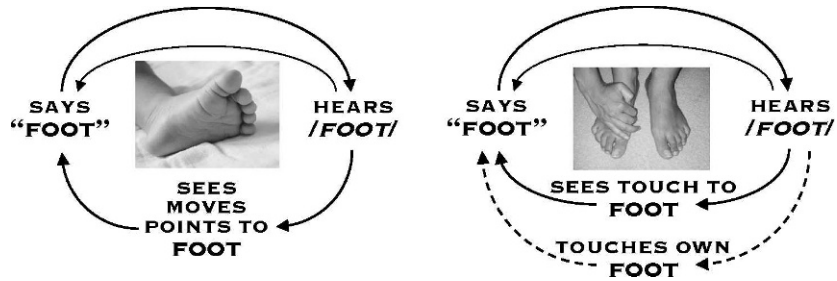

Fig. 1. (adapted from Horne & Lowe, 1996, p. 201). *Left Panel:* A child, who has learned to name *foot*, sees her foot, and then says ''foot''. Upon hearing this self-produced verbal stimulus /foot/, the child shows conventional listener behavior; she orients to the foot, moves it, touches it, and so on. Thus naming can be evoked by seeing a foot or hearing /foot/; it can be re-evoked by seeing a foot again or through self-echoing. This illustrates the bidirectional relation between the tact, listener behavior, and the object, or a class of objects or events. *Right Panel:* In an imitation task, seeing the experimenter touch her foot may evoke the child's naming of this body-part. Thus a child may covertly or overtly say ''foot''; hearing her own utterance /foot/ may then direct the child's attention to her own foot, leading her to touch this location on her own body (listener behavior). This illustrates how an apparently emergent matching response may come about as the result of naming.

Tir Na n'Og in Bangor at least 2 days a week were recruited by parental consent to participate in this experiment. Participants are referred to by short alternative names to preserve confidentiality. At the start of tact training they were aged 33 months (Emma), 34 months (Anna), and 35 months (Mol). Table 1 shows the total number of sessions administered to each child, their ages at the end of the procedure, and the General Quotient scores on the Griffiths Mental Developmental Scales (Luiz et al., 2006) obtained for 2 of the children (the remaining child left the nursery before this test could be administered).

Settings and Apparatus

Sessions were conducted in a specially designed quiet testing room at the nursery. During the sessions, the child and the experimenter sat comfortably in an inflatable boat, on beanbags, facing each other. A large teddy bear toy (Teddy) was seated on the edge of the boat, facing the child. Age appropriate toys and stickers were used during play breaks between test trials and after testing. These items were kept hidden in a closed box and in Teddy's backpack between presentations. Two wall-mounted digital video cameras were employed to record the behavior of the child and the experimenter. Audio and visual inputs from the two cameras and a hidden radio microphone were fed into a split-screen video recorder located in a separate audiovisual suite. JVC SR-VS10 VHS/DV recorders, with stop- and slow-motion viewing facilities, were used for recording and coding.

The visual stimuli employed were manual gestures performed live by the experimenter (see Table 2). These gestures consisted of touches to different parts of the body and were chosen based on the relative frequencies with which they appear in the naming (tact and listener) repertoires of 2- to 3-year-old children (see Camões-Costa et al., 2010). Thus, the touches to body parts that feature most frequently in children's naming repertoires were designated as baseline gestures; conversely, the touches to body parts that seldom evoke correct tact and listener responses were employed as target gestures.

Procedure

A multiple-baseline procedure was employed; each child participated in all conditions of the experiment. Training was presented to the children in a staggered manner to demonstrate experimental control of any resulting changes in target behavior. The flow of the procedure is illustrated in Figure 2 (left panel).

Baseline Matching Training and Identification of Novel Targets

Familiarization. The experimenter established a good rapport with the children during unstructured daily play sessions in the nursery playroom before inviting each child to participate in one-to-one play with toys in the test room. The child was asked to show Teddy what

Table 1

Children's gender, target relations assigned to each participant, ages at start of naming intervention in Experiment 1, 2 or 3, total number of sessions administered in each experiment, and children's general quotient scores on the Griffiths Mental Developmental Scales (GMDS).

	Participant	Gender	Target relations	Age at start of training (months/days)	Total number of sessions administered	Age at end of testing (months/days)	GQ scores
Experiment 1	Emma	Female	T2, T5, T6, T8	33/00	70 sessions	35/11	117
	Anna	Female	T1, T4, T7, T8	34/14	57 sessions	36/08	____
	Mol	Female	T3, T5, T8, T9	35/29	113 sessions	38/16	120
Experiment 2	Jack	Male	T2, T4, T9, T14	31/17	79 sessions	35/16	132
	Gina	Female	T2, T7, T8, T10	31/24	85 sessions	36/01	120
	Mila	Female	T1, T4, T11, T14	33/24	80 sessions	37/24	120
Experiment 3	Fin	Male	T3, T7, T8, T9	28/03	44 sessions	30/10	110
	Carl	Male	T2, T3, T8, T9	32/04	51 sessions	35/14	116
	Fex	Male	T2, T8, T12, T13	34/07	83 sessions	38/22	113

the experimenter was doing by repeating the actions shown; the experimenter said, ''Can you show Teddy how you do this?'' before commencing the first trial. The experimenter modeled eight different hand-to-body gestures twice per session and instructed the child to ''Do this'' before she presented each gesture. The body parts touched by the experimenter on modeling trials were those that did not feature frequently in the naming repertoires of young children who attended the nursery (see Camões-Costa et al., 2010). At this early stage of the procedure, the experimenter determined which of the corresponding hand-to-body touches were not part of the individual children's trained matching repertoires and could therefore be employed as target gestures in the experiment (see Horne & Erjavec, 2007). If the child correctly matched a gesture more than once during the first two sessions of its presentation, this indicated that the gesture already featured in the child's trained matching repertoire, and consequently this target body-part touch was replaced with another; the replacement gestures were likewise tested over two sessions. This continued until four novel target gestures were identified for each child. No reinforcers were delivered following any of the children's responses (accurate matches or mismatches), but the children were allowed to play with Teddy's toys at the end of each session. In this and subsequent training conditions, children were tested at least three times a week. Each session lasted approximately 15–20 min.

Baseline matching training. This condition established reliable, prompt, and correct matching responding to the verbal request, ''Do this,'' followed by modeling of a hand-to-body gesture on each trial. The details of this part of the procedure were presented in previous publications (see Erjavec et al., 2009; Horne & Erjavec, 2007) and only a summary is provided here: In each training session there were three modeling trials of each of the four baseline gestures (12 trials per session), with up to three presentations of the modeled gesture per trial (as necessary). The modeled gestures were presented in a predetermined randomized order, with the added constraint that no more than two trials of the same gesture could occur in succession. Matching of the four baseline gestures was trained under continuous reinforcement, to a criterion of 5 out of 6 correct responses per gesture, over two consecutive sessions. When matching performance met the 100% reinforcement criterion, reinforcement rate was reduced to 50% on a variable-ratio 2 (VR 2) schedule. The intermittent reinforcement criterion was 11 out of 12 correct responses across three trials per gesture within a single session.

Matching tests: Target (and baseline) gestures. Next, the children were presented with two modeling trials of each of four untrained target gestures and each of four trained baseline gestures; target and baseline trials were delivered in a prerandomized sequence (total of 16 trials per session). At the start of each session the experimenter asked, ''Shall we play the game?'' and before she modeled each gesture she prompted the child, ''Can you do this?'' Children's correct matching responses to baseline models were intermittently reinforced on a VR 2 schedule, but their

Table 2

Description of movement modeled and accepted responses variations for each baseline gesture (B1–B4) and target gesture (T1–T15) used during training and testing. The experimenter always used her left hand for modeling hand-to-body touches but children could respond with either hand.

Baseline/Target gestures	Behavior modeled by the experimenter	Accepted response variations
B1 Nose	Tips of fingers touching nose	Touching nose
B2 Ear	Tips of fingers touching right ear	Touching either ipsilateral or contralateral ear
B3 Neck	Tips of fingers touching neck (Adam's apple)	Touching anywhere on the neck
B4 Lips	Tips of fingers touching lips	Touching any area of the lips
T1 Temple	Tips of fingers touching right temple	Touching either ipsilateral or countralateral temple (excluding head/hair, forehead and ear)
T2 Bridge of foot	Tips of fingers touching bridge (arch) of right foot	Touching contralateral bridge of the foot (excluding top of foot, sole, toes and heel)
T3 Armpit	Tips of fingers touching right armpit	Touching contralateral armpit (excluding upper arm)
T4 Thigh	Tips of fingers touching middle of left thigh	Touching ipsilateral thigh (excluding knee and hip)
T5 Crook of arm	Tips of fingers touching crook of right arm	Touching crook of contralateral arm (excluding lower and upper arm)
T6 Crown	Tips of fingers touching middle of crown	Touching the top of the head (excluding forehead, back of the head, or temple)
T7 Ankle	Tips of fingers touching left ankle bone	Touching the area of either ankle (excluding shin, calf or any part of the foot)
T8 Wrist	Tips of fingers touching right wrist	Touching contralateral wrist (excluding lower arm and back of the hand)
T9 Upper arm	Tips of fingers touching middle of right upper arm	Touching contralateral upper arm (excluding crock of arm and shoulder)
T10 Lower arm	Tips of fingers touching middle of right lower arm	Touching contralateral lower arm (excluding crock of arm, elbow, wrist and pulse)
T11 Shin	Tips of fingers touching middle of left shin	Touching shin area of either leg (excluding ankle, top, side or back of the knee and calf)
T12 Calf	Tips of fingers touching middle of right calf	Touching calf area of either leg (excluding ankle, shin, and top, side or back of the knee)
T13 Thumb	Tip of index finger touching middle of right thumb	Touching or grabbing contralateral thumb (excluding other fingers)
T14 Hip	Tips of fingers touching middle of right hip bone	Touching hip area (excluding waist line or top of thigh)

responses to the target models were never reinforced. In the first two sessions only, any target gestures to which more than one correct response was emitted were replaced, to ensure that none of the targets featured in the children's (extraexperimentally) trained matching repertoires. The criterion for performance of the baseline gestures was 13 out of 16 (81%) correct over two consecutive sessions. If the criterion was not met, the experimenter was required to retrain baseline responding before conducting the next test session—however, this was not necessary in this or any subsequent conditions of the study.

The number of test sessions was staggered across the participants; they received either three, or six, or nine sessions before moving on to the next training condition. This allowed the effects of the subsequent interventions to be compared with those of repeated unreinforced presentations of the target gestures, and to control for nonexperimental events that may occur over time.

Tact Training: Target Locations on the Child

The aim of this training condition was to determine whether teaching the children to tact each of the four target locations *on their own body* would facilitate their matching of the modeled touches to those same locations *on the experimenter's body* on subsequent matching test trials. This tested the hypothesis that naming of target body locations can be instrumental in children's production of matching responses.

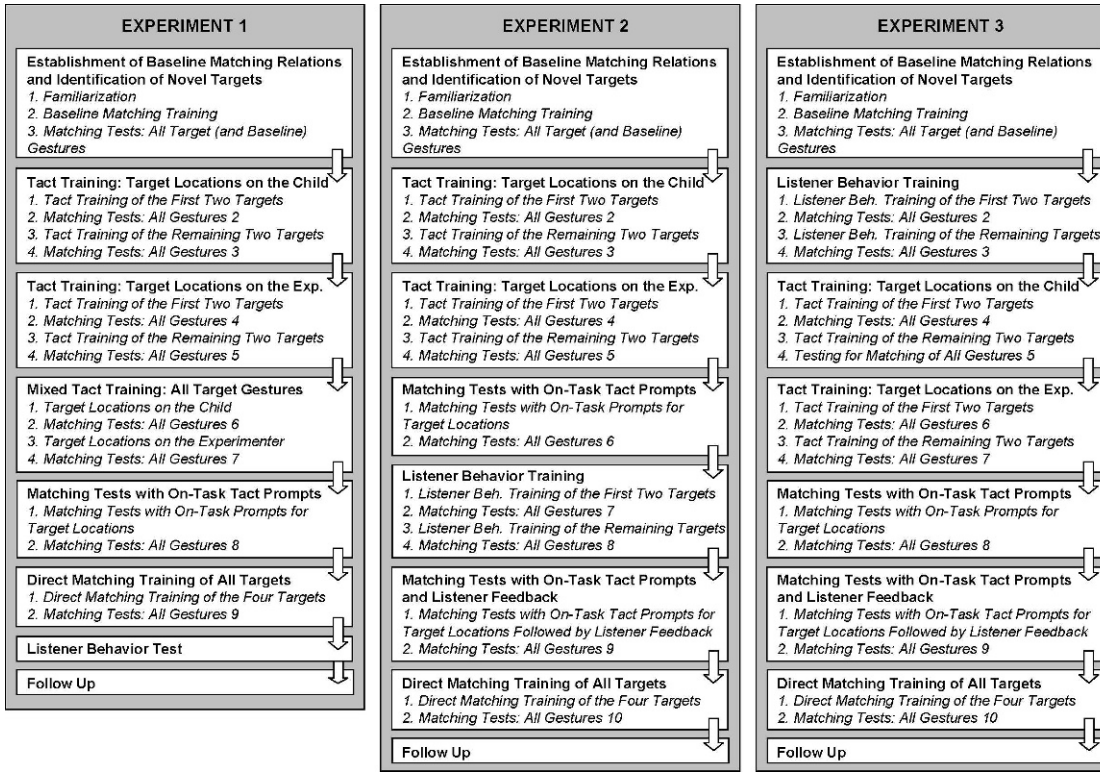

Fig. 2. Flowcharts showing the stages of Experiment 1, Experiment 2, and Experiment 3.

Tact training was administered in two stages for each child. First, the child was trained to accurately tact two of the four target body parts. The experimenter pointed to a target location on the child's body (e.g., thumb) and said, ''Look! Tell Teddy what this is called?'' If the child responded correctly, the experimenter exclaimed enthusiastically, ''Yes, it is the thumb! Clever girl!'' Occasionally (on 33% of trials) she also presented a toy for the child to play with as additional reinforcement. If the child produced an incorrect tact or no tact, the experimenter stated, ''This is the thumb,'' before asking the child, ''Can you say thumb?'' If the child failed to respond, the experimenter repeated presentation of the latter training sequence up to two more times on each trial before moving onto the next. Tact trials for each target location were alternated in the training sessions in a prerandomized sequence. As tact responding became more proficient, the experimenter's prompt was abbreviated to, ''What is this?'' and the reinforcement rate was reduced to 25%. Finally, the child's tact responses were tested in extinction. The criterion was seven out of eight correct tact responses per target body location.

Following this, three test sessions for matching of target (and baseline) gestures were conducted, as described earlier (see *Matching tests: Target (and baseline) gestures*). In this and all subsequent test blocks, if the child matched each target gesture on at least four out of six trials over three test sessions—showing consistent matching of all target gestures—the remaining training and test conditions would not have been administered; instead, the child would have progressed to the final tests (*Listener Test* and *Follow Up*; see below).

The second stage of the tact training condition was administered next; the child was trained to tact the remaining two target body locations, exactly as described for the first two, followed by another three-session block of matching tests.

Tact Training: Target Locations on the Experimenter

The aim of this condition was to determine whether teaching the children to tact each of

the four target locations *on the experimenter's body* would facilitate their matching of the modeled touches to those same locations on subsequent matching test trials.

Procedurally, this tact training condition was identical to the previous one, except that the experimenter pointed to the target locations on her own body, rather than on the child's body, while training the child to produce the target tacts. As in the previous training condition, tact training was first administered to criterion for two of the target body locations, followed by a three-session block of matching tests. This was followed by tact training of the remaining two target locations, and by three more sessions of matching tests.

Mixed Tact Training: All Target Gestures

The aim of this training condition was to ensure that the tact responses trained previously were maintained over time for all four target body locations, regardless of whether these were on the experimenter's or the child's body.

Target locations on the child. This training was also administered in two stages. First, one tact test trial was conducted for each of the four target locations. If the child responded correctly on all four trials, matching tests were readministered. If any errors occurred on the tact test trials, mixed tact training was conducted at a progressively thinner reinforcement schedule until criterion was reached in extinction—the child produced at least 11 correct responses over 12 consecutive tact trials, across the four targets, with 3 trials per target body location. The matching tests were then administered, exactly as before, except that from this point onwards in the procedure the four tact responses to the child's body parts were probed once each before each test session to establish that tact responding to all target locations was maintained. If tact performance fell below criterion, mixed tact training was readministered and criterion performance reestablished before proceeding; if the child responded correctly to the four tact probes, one matching test was conducted. Probing for tact responses and matching tests was repeated until three test sessions were completed.

Target locations on the child and the experimenter. One tact test trial was conducted for each target location (four per child and corresponding four per experimenter). If tact performance was errorless a matching test was conducted. If any errors were recorded, mixed tact training was administered to criterion (as described above). Thus at this point, prior to each matching test session, the child was required to show errorless tacting of all target locations that the experimenter pointed at on the child's body and on her own body. In order to evaluate the effects of repeated matching tests over time on the accuracy of children's matching of target gestures, and to compare these with the effects of the next intervention, the number of matching test sessions was staggered across children; they completed three, or six, or nine sessions before proceeding to the next training condition.

Matching Tests with On-Task Tact Prompts for Target Locations

The aim of this training condition was to determine whether children's untrained matching would become more accurate if, on each matching trial, the experimenter touched a target location on her own body and maintained this gesture while she asked the child to tact that target location then prompted the child to touch the same location on her own body.

The children were once again invited to teach Teddy about body parts. Tact performance was reviewed and if necessary retrained (as in *Mixed Tact Training: All Target Gestures*). After the child demonstrated errorless tact responding, a matching test session was conducted in the same way as for previous matching tests except that the experimenter provided tact prompts during modeling of the corresponding target gestures. There were three trials per target gesture (12 trials per session). On each trial, the experimenter first said, ''What's this?'' while pointing to a target location on herself. If the child did not respond within 3s, the experimenter prompted the child to do so by saying ''Tell me!'' up to two more times. If the child responded incorrectly, the experimenter provided corrective feedback as in previous tact training. When the child produced a correct tact, the modeling instruction was presented, up to three times, as needed; if the child still did not respond, the next trial was presented. As in previous matching tests, there were no scheduled consequences for any of the child's responses to the modeled target gestures. Each child completed three sessions.

Next, the children were presented with matching tests, without tact probes, as in the

previous conditions; the number of sessions was once again staggered across the 3 children (three, six, or nine sessions were administered).

Direct Matching Training of All Target Gestures

The aim of this training condition was to establish whether children's responses to all target models in the matching tests could be further improved by matching training.

The matching training of target gestures was conducted in much the same way as for baseline gestures at the outset of the study (see *Baseline Matching Training*). Shaping and ''putting-through'' procedures were used when necessary. As each child's performance became more accurate, the experimenter gradually reduced the reinforcement rate. Matching training was complete when a child produced 11 out of 12 correct responses across the four target gestures, tested in extinction. This was followed by three matching test sessions.

Listener Behavior Test

A listener behavior test was conducted to determine whether the children's success on the matching task (i.e., before direct matching training) correlated with their listener responses to the named target locations on the child's body. One session was administered with 4 trials per target body location (16 trials in all) presented in a predetermined randomized order. On each trial, the experimenter asked the child to touch a named body location (e.g., ''Can you touch your wrist?''). There were up to three prompts per trial, if necessary, and the children's listener responses were not reinforced or corrected.

Follow Up

One matching test session was administered every 2 to 3 weeks, until five sessions were conducted. This completed the experimental procedure.

Coding of Children's Responses

Each session was recorded on videotape and coded using predetermined response criteria to identify, on each training and test trial, whether a child produced a correct response, an incorrect response, or failed to emit a response. The movement sequences considered as correct responses to each modeled gesture and listener prompts are listed in Table 2. For each target, the boundary with other targets was pre-set in a manner that enabled the coders to determine whether a child's response on a matching trial approximated the antecedent model as opposed to any other target or baseline model, or none of these. The response criteria excluded behaviors that children naturally produce at this age, such as clapping, kicking, touching clothes or near objects, extending hands, mouthing fingers, rubbing eyes, and scratching any part of the body. If a child performed a correct response immediately after an incorrect response, it was coded as a ''self-correction'' and counted as correct in the final analyses. Conversely, an incorrect response emitted immediately after a correct response was coded as a ''correct-to-incorrect'' and counted as incorrect (see Erjavec & Horne, 2008; Horne & Erjavec, 2007). Such multiple responses were very infrequent. In matching test sessions, they occurred on 3% of baseline trials (range: 2–6%) and on 3% of target trials (range: 2–5%). Overall, self-corrections were scored eight times more frequently than correct-to-incorrect responses. Children's tact responses also needed to be entirely correct.

Also recorded was whether a reinforcer was delivered on a particular baseline gesture matching trial, the number of models (one, two, or three) per trial required to evoke a response, and the form of each incorrect response.

Interobserver Agreement

A second scorer, familiar with infant research but blind to the aims of the present experiment, independently coded 25% of sessions selected on a random basis. Interobserver agreement was calculated for each training and test phase by dividing the number of agreements by the total number of coded responses then multiplying the result by 100. An agreement was defined as two independent observers assigning the same response code on a given trial. Agreement per phase ranged from 98% to 100%.

Results and Discussion

Children's Matching of Baseline Gestures

The four trained matching relations for all children are listed in Table 2 (top panel). Each child completed training in three sessions

(the minimum required by the mastery criteria, see Procedure). The children continued to respond correctly to baseline models throughout the procedure in all conditions (see Figures 3, 4, and 5).

Children's Performance in Tact Training Sessions

Across 3 children and 12 target behaviors, the children learned to tact the relevant locations on their own bodies in an average of 26 trials (range: 5–78 trials). Many fewer trials were needed to subsequently train tact responses for the corresponding target locations on the experimenter's body (8 trials on average; range: 0–19 trials). This pattern of results was observed in each child's data (see Figures 3, 4, and 5). Indeed, after tact training on the child's body, several of these tacts (3 for Anna and 3 for Emma) were in place at the outset of tact training on the experimenter's body; for these tacts, Anna and Emma did not require mixed tact training. Mol's tact relations were more fragile and all required extensive mixed training (see Figure 4).

Overall, the results show that tact training often generalized from target locations on the child's body to the corresponding locations on the experimenter's body; this effect ranged from moderate savings in the number of training trials required to establish each tact to full emergence of tacts without training.

Children's Matching of Target Gestures

The sets of four gestures that were identified as targets for each child are listed in Table 1 and described in Table 2 (bottom panel). Children's matching of each target gesture in the test trials was classified as either (i) *consistent*, if correct on at least two-thirds (66–100%) of the trials; (ii) *intermittent* (33–66% correct trials); (iii) *infrequent* (1–32% correct trials); and (iv) *unmatched* (no matches). Note that for each child, the number of matching tests following each training condition may differ between targets, in accordance with the staggered and pair-wise introduction of the independent variables (e.g., tact training on the child's body) throughout the procedure. Therefore, in order to calculate percent matching per phase for each target, matching responses were summed over all the matching tests that were conducted immediately after one training phase and before the beginning of the next.

In the matching tests that followed *baseline matching training* and prior to the first round of tact training (i.e., across Test 1 sessions for the first pair of targets, and Test 1 and Test 2 for the second pair of targets), out of a total of 12 untrained target gestures across all 3 children, 6 were infrequently matched, and the remaining 6 were not matched at all. Our data show no evidence that repeated modeling of target gestures resulted in increased matching, which is consistent with our previous findings (Erjavec & Horne, 2008; Erjavec et al., 2009; Horne & Erjavec, 2007).

After staggered *target tact training on the child's body*, the children's matching performances improved for some of the gestures, but no target was matched consistently. Looking at Test 2 and Test 3 scores for the pairs of target gestures trained first, and at Test 3 and Test 4 scores for the pairs of gestures that were trained second for each child, 5 out of 12 targets were now matched intermittently, 6 infrequently, and 1 target was not matched (see Figures 3, 4, and 5). In the tests administered after staggered *target tact training on the experimenter's body*, but before the next round of training (i.e., across Test 4 and Test 5 for the first pair of targets, and in Test 5 for the second pair), the children matched 4 of their targets consistently, 1 intermittently, 5 infrequently, whereas 2 remaining targets were not matched. Next, following *mixed tact training of all target gestures on the child* (Test 6), the children matched 6 of the targets consistently, 2 intermittently, and 4 infrequently. Finally, following *mixed tact training of all target gestures on the experimenter* (Test 7), the children matched 5 of the targets consistently, 2 intermittently, and 5 infrequently. Clearly, tact training administered in the absence of modeling was effective in establishing and/or increasing matching of untrained target gestures in subsequent tests. However, after 20 (Emma), 25 (Anna), and 35 (Mia) tact training sessions, consistent matching—defined a priori as correct responding on at least two thirds of trials (see Procedure)—did not develop across all targets for any of the participants. The data show no evidence that training the children to tact the target locations on the experimenter's body resulted in larger improvements in their matching of the target gestures than when they were trained to tact these same locations on their own bodies.

The children were next taught to tact the location touched by the modeler before they

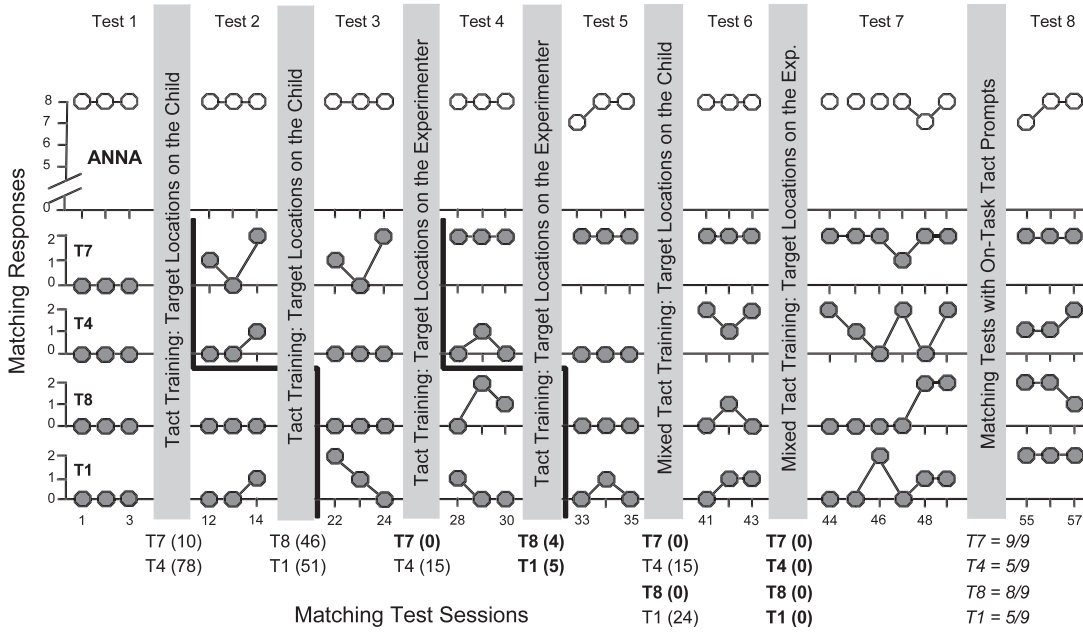

Fig. 3. Correct matching responses emitted by Anna in the eight baseline trials (plotted together at the top of each figure and represented by open circles) and the eight target trials (plotted separately for the four target behaviors, with two trials per gesture, and represented by filled circles) presented during each session of the multiple baseline procedure in Experiment 1. Training and testing was administered in a staggered manner (see text) over five experimental training conditions. Each training phase is labeled and denoted by a shaded area; the bold lines indicate where training was applied in a staggered manner to pairs of target actions. Underneath, the number of training trials that needed to be administered before criterion performance was attained (T) and the proportion of trials on which a child responded correctly in probing sessions *(T)* are presented for each target gesture. Bold figures indicate the relations that were in place at the outset (i.e., only 0–5 trials were required to reach criterion performance).

responded to the ''Do this'' matching prompt on test trials. This intervention aimed to increase the incidence of (covert) naming of the target body locations during subsequent (unprompted) matching tests. In matching tests following this intervention (Test 8), the children matched 6 out of 12 target gestures consistently; 2 intermittently, 3 infrequently, and 1 target was not matched. However, this tact-prompt intervention was sufficient to establish consistent matching for 1 child, Anna, across all of her target gestures (see Figure 3). The remaining 2 participants required direct matching training, administered next. As expected, direct matching training resulted in consistent matching of all target behaviors for these 2 children (see Test 9 for Mol, Figure 4, and Emma, Figure 5); this outcome replicated our previous findings (Erjavec et al., 2009; Horne & Erjavec, 2007).

Two children participated in the listener-behavior test. On 16 trials per child, responding was 100% for Mol and 94% for Emma, showing that listener responses, which were never directly trained, emerged as a result of tact training. This is consistent with the existing literature (e.g., Horne et al., 2007; Lowe et al., 2002, 2005) and predictions of the naming account of Horne and Lowe (1996). Due to her leaving the nursery, Anna did not take part in either *Listener* or *Follow Up* tests.

In the Follow Up, Emma and Mol were presented with one matching test session every 2 to 3 weeks until five sessions had been conducted. On average they matched two of their eight targets at 100%, 3 consistently, and the remaining 3 intermittently. This shows that the majority of the target matches, when directly trained, were well maintained over the following 3 months in the absence of reinforcement or corrections. Children's incorrect responses on all matching test trials were noted and examined. These responses are reported in Appendix A. The children often touched, in response to the target model, the body parts adjacent to the target

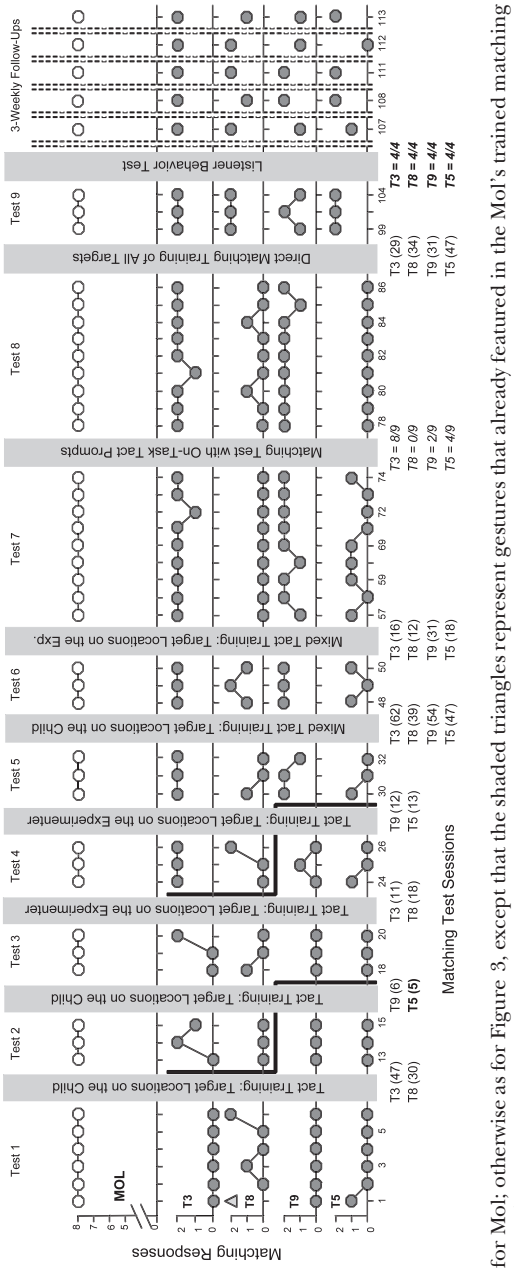

Fig. 4. Data for Mol; otherwise as for Figure 3, except that the shaded triangles represent gestures that already featured in the Mol's trained matching repertoire which were replaced by novel gestures.

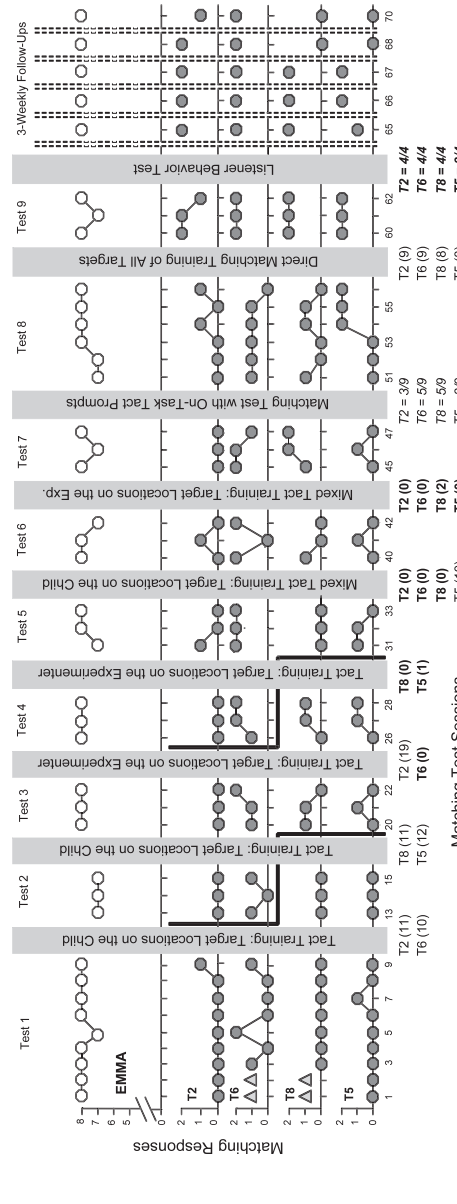

Fig. 5. Data for Emma; otherwise as for Figure 4.

location, showing lack of discrimination between specific body locations. For example, in response to modeled touches to the armpit, Mol touched her tummy on 32%, her chest on 23% and her upper arm on 26% of trials. Theoretically at least, listener behavior training, which includes manual correction following errors, might be expected to improve discrimination between body parts. This was investigated in the next two experiments.

EXPERIMENT 2

Method

Participants

Two typically developing girls, Gina (31 months) and Mila (33 months) and one boy, Jack (31 months) took part.

Settings, Apparatus, and Procedure

The setting and apparatus were as described in Experiment 1. The baseline and target behaviors allocated to each child are shown in Table 1. The flow of the experimental procedure is illustrated in Figure 2 (middle panel). The sequence of interventions was: (i) baseline matching training; (ii) tact training (locations on the child and experimenter); (iii) tact prompts during matching tests; (iv) listener training; and (v) tact prompts with naming feedback. As an addition to the procedure described for Experiment 1, it was planned to review previously trained tact and listener behavior responses at the start of each matching test, and if necessary retrain them. However, this prolonged the procedure, reducing the children's willingness to participate; tact/listener reviews were therefore administered only prior to the first, fourth, and seventh matching test sessions presented after each intervention. These reviews were also administered prior to any new training/intervention, which made the mixed tact training sessions administered in Experiment 1 unnecessary.

Listener Behavior Training

Listener behavior training was administered in two stages for each child. First, the child was trained to respond accurately to the names for two of the four target body locations. The experimenter asked ''Can you show Teddy where is your (target body-part name)?'' then waited for the child to respond. If the child touched the correct location, the experimenter exclaimed enthusiastically, ''Yes, that's right. Clever girl (or boy)!'' and occasionally also gave the child a toy to play with. Otherwise, the experimenter said, ''Here it is!'' and moved the child's hand to touch the appropriate location, before asking the child again, ''So, can you now touch your (repeat target body-part name)?'' A correct touch was reinforced; if the child failed to respond, the latter training sequence was repeated up to two more times on each trial. Listener trials for each target location were alternated in each training session in a prerandomized sequence. As the child became more proficient at correctly locating the named body parts, the experimenter gradually faded the prompts, and reduced the reinforcement rate to 25%. Finally, the child's listener behavior was tested in extinction. The criterion was seven out of eight correct trials per body part.

After listener training for the first two target locations was completed, three matching tests were conducted as described in *Matching tests: Target (and baseline) gestures.* Next, listener training was conducted for the remaining two target locations, followed by matching tests, staggered across children.

Matching Tests with On-Task Tact Prompts for Target Locations and Naming Feedback

The aim of this training condition was to determine whether the children's untrained matching would become more accurate if on each matching trial (i) the child first tacted accurately the target location, and (ii) following a correct matching response the experimenter provided feedback by saying, ''Well done, you're touching your (target body-part)''. Nine such trials were conducted for each target location, followed by another block of matching tests.

Finally, direct matching training and follow up tests were implemented as in Experiment 1.

Coding and Interobserver Agreement

Children's responses were coded according to the criteria described for Experiment 1. In the matching test sessions, multiple responses occurred on 4% of baseline trials (range: 3–5%) and on 4% of target trials (range: 3–5%). Overall, self-corrections were scored four times more frequently than correct-to-incorrect responses.

A second scorer independently coded 32% of sessions selected on a random basis. Interobserver agreement in each phase ranged from 95% to 100%.

Results and Discussion

Children's Matching of Baseline Gestures

The four gestures that were trained as baseline matching relations to all children were the same as in Experiment 1 (see Table 2, top panel). Each child completed matching training in the minimum three sessions. The children continued to respond correctly to baseline models in all tests (see Figures 6, 7, and 8).

Children's Performance in Tact and Listener Behavior Training Sessions

Across 3 children and 12 target responses, the children learned to tact the target locations on their own bodies in an average of 27 trials (range: 6–61 trials). Replicating the results of Experiment 1, tacts trained on the child's body generalized to target locations on the experimenter's body. For Mila and Jack, all tacts were at criterion without training (see Figure 6 and 7, respectively), and the remaining child (Gina) required 5–19 trials to meet the criterion, considerably fewer than in the preceding target tact training on her own body (see Figure 8).

It is well documented in the literature that tact training, administered to children of this age, establishes the whole naming relation; this is evident in the emergence of listener behavior in tests that use well established, simple responses such as pointing to a whole object (e.g., Lowe et al., 2002; 2005). By contrast, correct listener responses in the present tests required children to make accurate discriminations between the adjacent body parts. Nevertheless, the data show that Mila and Jack emitted correct listener responses to half of their target locations on the first trial; the remaining listener responses required only 13 trials, on average, to reach criterion performance (range: 3–22 trials; see Figures 6, 7, and 8).

Children's Matching of Target Gestures

In the tests following baseline matching training, out of a total of 12 target gestures (across all children), 1 target was matched

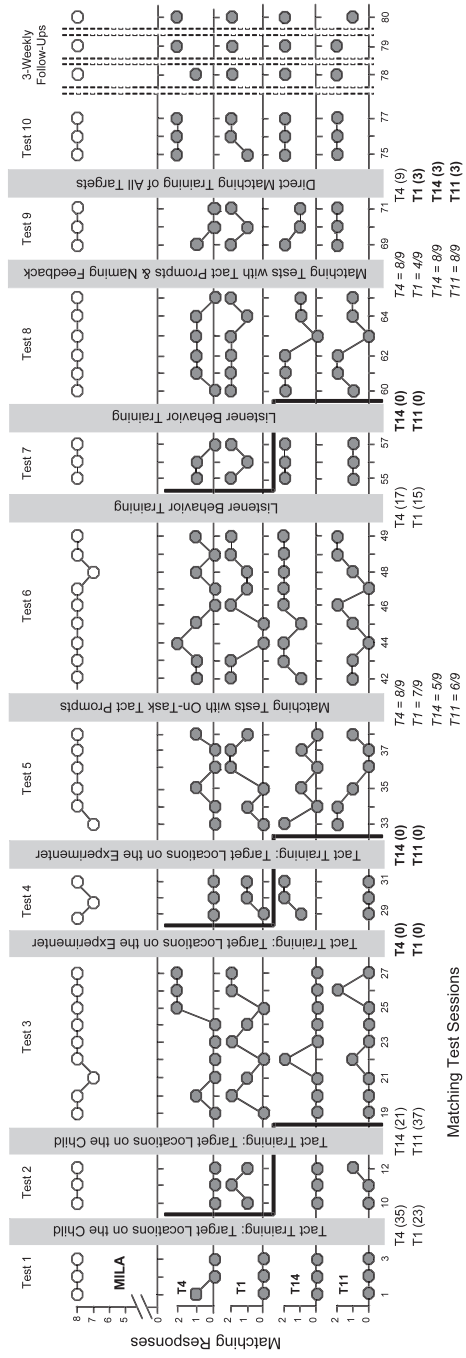

Fig. 6. Data for Mila. Otherwise as for previous figures.

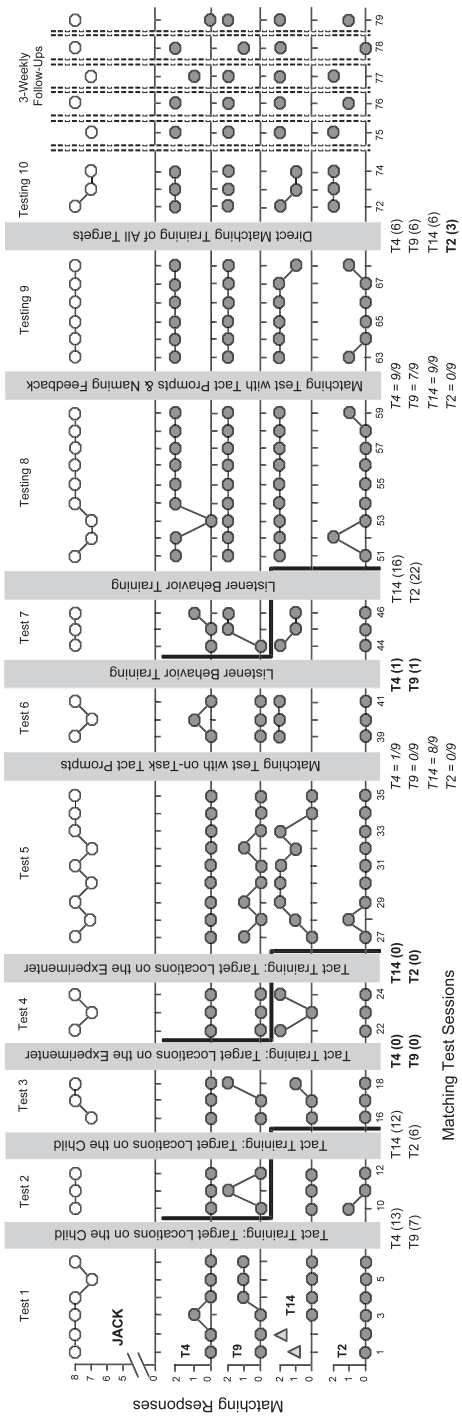

Fig. 7. Data for Jack; otherwise as for previous figures.

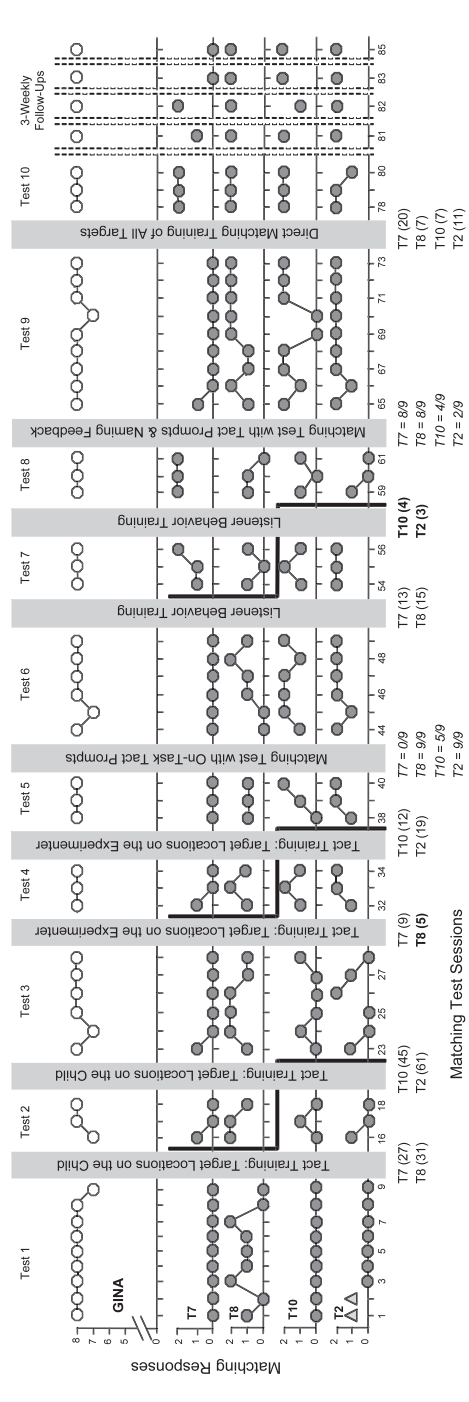

Fig. 8. Data for Gina; otherwise as for previous figures.

intermittently, 7 infrequently, and 4 remaining targets were not matched at all. As in Experiment 1, there was no evidence that repeated presentation of modeling and response opportunities led to improvements in children's matching of target gestures.

Following tact training of target locations on the child's body, one target gesture was matched consistently, three intermittently, six infrequently, and two remaining targets were not matched. After tact training of target locations on the experimenter's body, the children matched one target gesture consistently, six intermittently, four infrequently, and the remaining gesture was not matched. These data replicate the results of Experiment 1 and show that training the children to tact target locations resulted in some correct matching of target gestures in subsequent tests. However, as in Experiment 1, none of the children showed consistent matching across all of their target body parts.

In the tests administered after the on-task tact prompts intervention, the children matched five targets consistently, three intermittently, one infrequently, and three were not matched. Although this intervention increased children's correct matching of some targets, it was not sufficient to establish consistent matching of all gestures for any of the children (see Figures 6, 7, and 8). These results were similar to Experiment 1, in which only 1 participant consistently matched all target gestures at this point in the procedure.

Listener Behavior Training was administered next. In the matching tests that followed, 6 out of 12 targets were matched consistently, 4 intermittently, and 2 infrequently. Although children's matching continued to improve, none of the children consistently matched all of their target gestures. They proceeded to the next stage of training where on each trial the experimenter first evoked the child's tacting of target body location, then presented the matching prompt ''Do this'', and finally provided naming feedback for any correct matching responses. In the subsequent matching tests, the children consistently matched nine of their target gestures, but the remaining three were matched only infrequently. This intervention improved the children's performances considerably, but for each child one target gesture remained poorly matched (see Figures 6, 7, and 8). Therefore, direct matching training was conducted next.

Direct matching training resulted in consistent matching of all target behaviors for all children (12 targets in total) in repeated tests administered in extinction, as in Experiment 1. In Follow Up, all children were given one matching test session every 2 to 3 weeks. Across all children, 11 target gestures continued to be matched consistently in the first three follow ups, but by the fourth follow up there was evidence of deterioration in matching of two of the eight target gestures tested. At the fifth follow up, only two out of four targets tested were matched. This pattern of maintenance in extinction for some target matches, but decline in others, is similar to that in Experiment 1.

Children's incorrect responses on all matching test trials are reported in Appendix A. These data show that, as in Experiment 1, children's errors mostly consisted of touches to body parts adjacent to the target locations. Listener behavior training, which was intended to improve children's discriminations between adjacent target body parts, was administered late in the procedure. By the end of listener training Jack matched three of his four targets at close to 100%, but showed no improvement for his remaining target. Gina showed transient improvement of matching for one target, but a decline in another; and there was no discernible effect of listener training on Mina's target matching. The next experiment was designed to investigate whether listener behavior training may be more effective in improving children's matching of target gestures if administered earlier in the procedure. We also wanted to establish whether the effect of tact training, which was demonstrated in Experiment 1 and Experiment 2, would be greater if the children underwent tact training *after* they had learned listener responses for each target body part.

EXPERIMENT 3

Method

Participants

Three typically developing boys aged 28 months (Fin), 32 months (Carl), and 34 months (Fex) at the start of listener behavior training participated in this experiment (see Table 1).

Settings, Apparatus, and Procedure

The setting and apparatus was as described in Experiment 1. The baseline and target gestures allocated to each child are shown in Table 1.

The experiment consisted of the same training conditions described in Experiment 2, but in the following order: (i) listener behavior training; (ii) target tact training of the child's body and then on the experimenter's body; (iii) matching tests with on-task tact prompts for target locations; (iv) matching tests with on-task tact prompts for target locations and naming feedback; (v) direct matching training of all target gestures; and (vi) follow up sessions. The flow of the procedure is illustrated in Figure 2 (right panel). Testing and retraining (as needed) of tact and listener responses was conducted at the start of the matching test sessions as in Experiment 2.

Coding and Interobserver Agreement

Children's responses were coded as in Experiment 1. In the matching test sessions, multiple responses occurred on 6% of baseline trials (range: 3–8%) and on 4% of target trials (range: 3–6%). Overall, self-corrections were scored two times more frequently than correct-to-incorrect responses.

A second scorer independently coded 33% of sessions selected on a random basis. Interobserver agreement in each phase ranged from 99% to 100%.

Results and Discussion

Children's Matching of Baseline Gestures

Fex and Fin completed baseline matching training in three sessions (the minimum required to meet the criterion) and Carl needed four sessions to do so. Figures 9 and 10 show that the children continued to respond correctly to the baseline models in all tests.

Children's Performance in Listener Behavior and Tact Training Sessions

In this experiment, listener behavior training was administered first. Across 3 children and 12 target responses, training children to touch the correct body locations after hearing the experimenter's naming of these locations took 44 trials per target behavior, on average (range: 11–86 trials). Compared to tact responses trained first in Experiments 1 and 2 (accomplished in $M = 26/27$ trials), listener behavior was clearly more difficult to establish. A comparison between the present results and those of Experiment 2, where listener behavior training was administered late in the procedure, confirms that tact training had been effective in establishing and/or improving children's corresponding listener responses—4 out of 12 were in place at the outset of Experiment 2 listener training, 2 required only three or four training trials, and the remainder took many fewer trials to train ($M = 13$) than was the case in the present experiment ($M = 44$).

Likewise, the present data show that, once the children's listener responses were at criterion, in most cases the corresponding tact responses were either already in place or required very few trials to meet the set criterion (see Figures 9 and 10). At the start of tact training for target locations on the child's body, all four tacts were in place for Fex, three for Fin, and two for Carl; the remaining three tacts took between 8 and 10 trials to reach criterion. For the 2 children who underwent tact training for target locations on the experimenter's body, all eight tacts were in place at the outset. Overall, these data show that listener behavior training sufficed to establish naming of most target body locations, and that the resulting name relations included corresponding locations on the child's and the experimenter's bodies. This outcome differs from the findings of previous naming studies (Horne et al., 2004; 2006) in which listener training did not invariably result in the emergence of the corresponding tact relations.

Children's Matching of Target Gestures

The sets of four gestures that were identified as targets for each child are listed in Table 1 and described in Table 2 (bottom panel). In the generalized imitation tests conducted after baseline matching training, out of a total of 12 target gestures (across all children), 1 target was matched intermittently, 6 infrequently, and 5 were not matched at all. In the test sessions that followed listener behavior training, the children matched 4 of their targets consistently, 3 intermittently, and 4 infrequently; the remaining target was not matched. These data show that listener training, conducted in the absence of modeling, was effective in establishing or increasing matching of target gestures in the subsequent matching tests.

In the matching tests administered after tact training for target locations on the child's

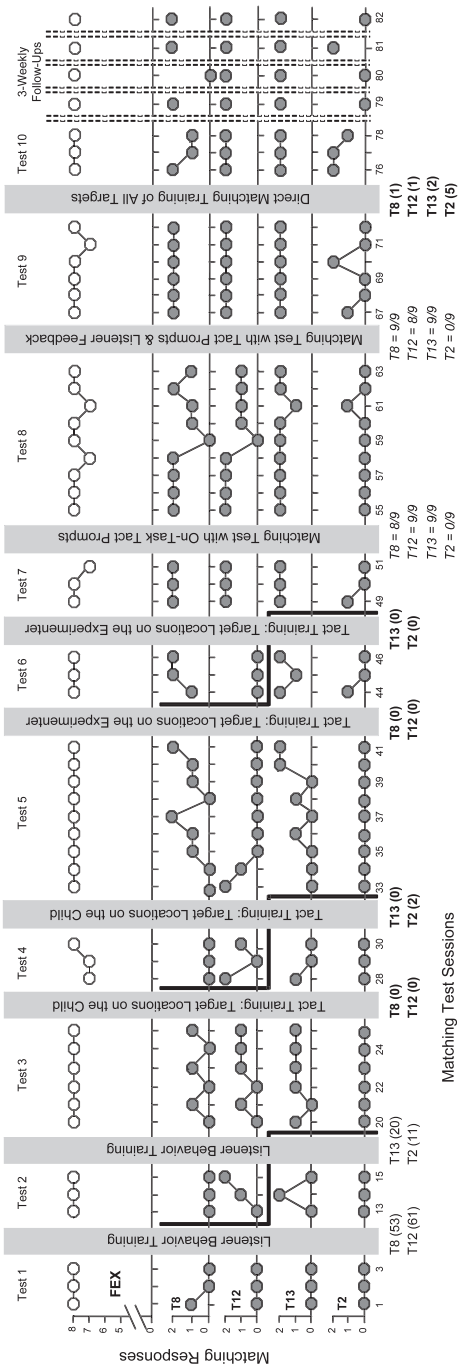

Fig. 9. Data for Fex; otherwise as for previous figures.

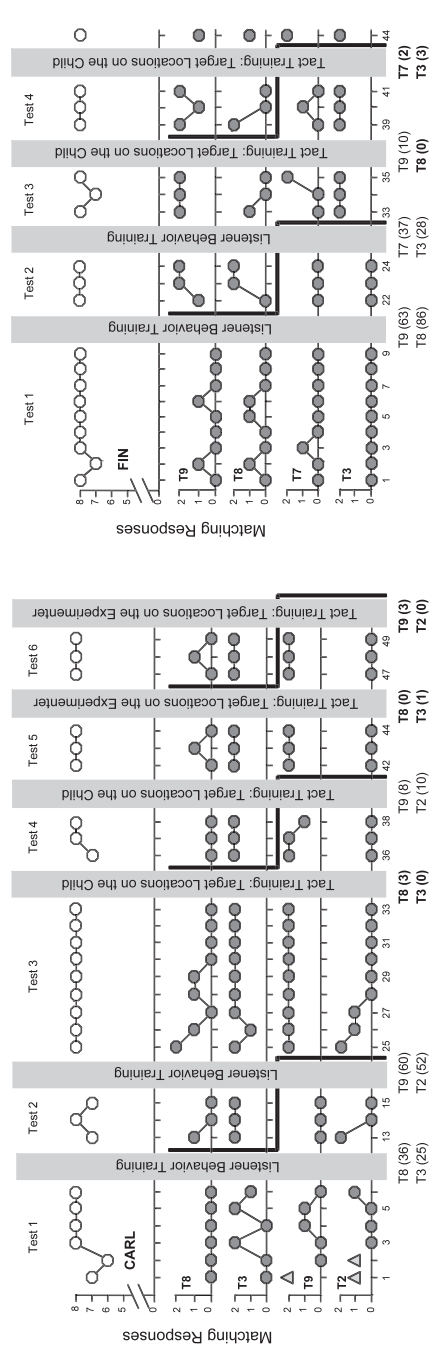

Fig. 10. Data for Fin, and Carl; otherwise as for previous figures.

body, 5 out of 12 targets were matched consistently, 3 intermittently, 3 infrequently, and 1 target was not matched. Fin participated in only one test session after tact training before dropping out of the study. Carl dropped out of the procedure after tact training of target locations on the experimenter's body was completed but before the subsequent matching test could be administered (see Figure 10). After tact training for target locations on the experimenter's body was completed, out of a total of six target gestures, three were matched consistently, one intermittently, and two infrequently. This pattern is similar to the results of the previous experiments—at the end of the tact training intervention, all children matched some of their target gestures consistently, but no child did so across all their targets.

Only one child, Fex, participated in the matching tests with on-task tact prompts for target locations intervention. In the generalized matching tests that followed, he matched three of his four target gestures consistently, but the remaining target infrequently. His performance was similar to those of 5 out of 6 participants in Experiment 1 and Experiment 2, who by the end of this intervention consistently matched most—but not all—target gestures. After the next intervention—matching tests with on-task tact prompts for target locations with naming feedback—was administered, Fex's matching was errorless for three of his targets, but the remaining gesture was still matched only infrequently. As in our previous studies, the direct matching training that followed resulted in consistent matching of all targets for this child. Over his four Follow-Up sessions, Fex matched three target gestures consistently, but the remaining gesture was once again matched only infrequently.

Children's incorrect responses on all matching test trials are reported in Appendix A; their pattern of errors was similar to those found in the previous two experiments.

Analysis of Children's Matching Responses Across All Experiments

Considering the results of Experiment 1, Experiment 2 and Experiment 3 together, there were 9 participants and 36 target behaviors. The percentages of children's correct matching responses to the experimenter's modeling of target gestures in repeated matching tests were analyzed statistically to explore the effects of various types of training administered in these experiments. In all cases where data were available for at least 3 participants, we calculated the effect sizes as indices of change across conditions; wherever the sample size was large enough (4 or more participants) we also employed repeated-measures t tests.

Effects of the Tact Training Interventions

Tact training administered before listener-behavior training. In Experiment 1 and Experiment 2, target tact training was administered on the child's body first, and then for the same locations on the experimenter's body. In Experiment 1, this was followed by a mixed tact-training intervention.

Across the 6 children and 24 target gestures in Experiment 1 and Experiment 2, mean target matching in all generalized imitation test sessions administered before target tact-training on the child's body was 8% (range: 6–13%). After this training, but before the next training commenced, matching was recorded on a mean of 27% of trials (range: 15–43%). Statistically, this difference was significant, $t(5) = -4.98$, $p = .004$, with a very large effect size (Cohen's $d = 2.94$; see Brace, Kemp, & Snelgar, 2006). Indeed, all children were more likely to match their target responses after this intervention. After target tact training on the experimenter's body, but before the next training commenced, target matching was recorded on a mean of 38% trials (range: 17–58%). The difference between the children's performances on the tests administered before and after this intervention was not statistically significant, $t(5) = -1.68$, $p = .152$, but the effect size was large (Cohen's $d = .90$). All children were more likely to match their target responses after this intervention.

Across 3 children and 12 target gestures in Experiment 1, in the test sessions prior to mixed tact training, mean target matching was 44% (range: 36–58%). After mixed tact training, but before the next training commenced, correct target matches were recorded on a mean of 51% trials (range: 38–58%). The effect size was medium ($d = .55$); only 1 child was more likely to emit correct target responses after this intervention.

Overall, these tests confirm that the tact training interventions significantly increased children's matching of target gestures; tact

training of target locations on the child's body, administered first, resulted in the biggest increases in target matching; the subsequent target tact training for the same locations on the experimenter's body, and mixed training, had smaller effects.

Tact training administered after listener behavior training. In Experiment 3, the children were given tact training later in the procedure, after listener behavior training. In their case, and across 12 target gestures, before target tact training on the child's body, mean target matching was 48% (range: 22–65%). After this tact training, correct target matches were recorded on a mean of 48% trials (range: 27–65%). The effect size was small ($d = 0.01$); only 1 child was more likely to match the target responses after this intervention, which clearly did not add to the effects of the earlier listener-behavior intervention (see below). Only 1 participant, Fex, also underwent target tact training on the experimenter; in his case, this intervention improved the percentage of correct matching across the four target gestures from 27% to 67%.

Effects of the Matching Tests with On-Task Tact Prompts for Target Locations

After tact training in all experiments, the children were presented with three sessions of matching tests with on-task tact prompts for target locations. All participants in Experiment 1 and Experiment 2, and 1 child in Experiment 3, took part. Across these 7 children and 28 target gestures, a mean of 45% (range: 17–67%) of target trials were matched in the test sessions conducted prior to the on-task naming prompts for matching intervention. After this intervention, but before the next, target matches were recorded on a mean of 55% trials (range: 31–88%). Statistically, this difference was not significant, $t(6) = -1.59$, $p = .164$. Only a medium effect size was obtained ($d = .57$) because only 4 children were more likely to emit correct target responses after this intervention.

Effects of the Listener Behavior Training Interventions

Listener-behavior training administered before tact training. In Experiment 3, listener behavior training was administered to 3 children, across 12 target behaviors. Prior to this intervention, the children responded correctly on 9% of the generalized imitation test trials (range: 3–17%). Following the intervention, but before the next training commenced, the children emitted correct matching responses on 48% of the trials (range: 22–65%). The effect size was very large ($d = 2.60$). Indeed, all children were more likely to match targets after the listener intervention.

Listener behavior training administered after tact training. In Experiment 2, across 3 children and 12 target gestures, mean target matching responses in the test sessions conducted prior to listener behavior training was 52% (range: 31–64%). Following listener training, but before the next training commenced, mean target matching increased to 59% (range: 47–71%). The effect size was small ($d = .47$) and only 1 child was more likely to emit correct target responses after the listener intervention.

Overall, listener behavior training, when administered first (Experiment 3), was very effective in increasing children's matching of target gestures in the subsequent tests; however, this training had no effect when administered later in the procedure (Experiment 2).

Effects of the On-Task Tact Prompts for Target Locations and Naming Feedback Intervention

In Experiment 2 and Experiment 3, after both listener behavior training and tact training were completed, the children were presented with three sessions of matching tests with on-task tact prompts for target locations followed by naming feedback. All participants in Experiment 2 and 1 child in Experiment 3 took part. Across these 4 children and 16 target gestures, mean target matching in the test sessions conducted prior to this intervention was 59% (range: 47–71%). After this intervention was administered, but before the next training commenced, target matches were recorded on a mean of 72% trials (range: 64–81%). Statistically, this difference was significant, $t(3) = -3.82$, $p = .032$, with a large effect size ($d = 1.48$). Indeed, all children were more likely to emit target responses after this intervention.

Joint Effects of All Naming Interventions

Considering all naming training that was administered to the participants in the three experiments—tact training and prompts in Experiment 1 and tact and listener training and prompts in Experiment 2 and Experiment

3—there were 7 participants who completed the experimental procedures. The 2 children who left the nursery before all scheduled interventions could be administered also completed a part of this training. Therefore, it was possible to compare the accuracy of 9 children's performances, across 36 target gestures, to estimate the overall effectiveness of name training.

Mean target matching in all generalized imitation test sessions prior to any intervention was 8% (range: 3–17%). After all naming interventions, but prior to the start of direct matching training, target matches were recorded on a mean of 65% test trials (range: 33–88%). Statistically, this difference was significant, $t(8) = -9.18$, $p < .001$, and the effect size was extremely large ($d = 5.40$); the effect was present for each child and across most of the target gestures.

The Effects of Direct Matching Training

Although all children's matching of target gestures showed large and significant increases following the naming interventions, only 1 child in Experiment 1 (Anna) developed consistent matching of all her target gestures as the result of tact training. To achieve this criterion, the remaining children needed to undergo direct matching training. Two children in Experiment 1, 3 children in Experiment 2, and 1 child in Experiment 3 participated in this intervention. Across these 6 children and 24 target gestures, mean target matching in all matching test sessions administered prior to direct matching training was 62% (range: 33–81%). After matching training, matching occurred on a mean of 93% test trials (range: 88–96%). Statistically, this difference was significant, $t(5) = -3.86$, $p = .012$, and the effect size was very large ($d = 2.96$); the effect was present for each child.

GENERAL DISCUSSION

In the present study we aimed to investigate whether training young children to name four target body parts would be sufficient for the children to match, for the first time, an adult's touches to those locations during a generalized imitation test. The series of three experiments we report were designed to test this naming hypothesis by comparing imitation of novel target gestures by children who either (i) had learned to name them or (ii) only responded as listeners to those names. If untrained imitation emerged only in children who had learned to name the target stimuli this would provide evidence that target naming is sufficient whereas the corresponding listener behavior is not. However, our data show that all 9 children acquired both the tact and listener components regardless of whether they were ostensibly trained the tacts (Experiment 1 and Experiment 2) or corresponding listener relations (Experiment 3) at the outset. Consequently, we assume that both the tact and listener training established naming and our analysis of whether naming can in turn establish matching of novel targets when these are presented in the context of a generalized imitation task must rest on whether there was a significant change in the level of target matching after target naming was established during the experiments.

The Effects of All Naming Interventions on Novel Target Matching

The effects of the naming interventions so defined were analyzed statistically for the combined data from all 9 children who participated in the three experiments, thereby encompassing potential untrained matching of 36 novel target behaviors. The analyses showed that before the naming interventions were introduced, mean target behavior matching was only 8% in the generalized imitation tests. This initial low level of target matching, here over as many as 12 successive generalized imitation tests, replicates the findings reported in our earlier studies on generalized imitation (Erjavec et al., 2009; Horne & Erjavec, 2007). However, in the generalized imitation tests conducted after all the naming interventions had been implemented, target-matching responses had increased to a mean of 65%. This was a significant change with an extremely large effect size—and the increase in target matching occurred in all children. Behavior change of this order is impressive given that target matching was always tested under extinction.

Limitations on the Effects of Naming Interventions

Although the above data suggest that target naming had a large and significant effect on the development of children's untrained matching of the novel target behaviors, with

1 child, Anna (Experiment 1) showing near perfect matching following the naming interventions, the untrained matching performances of the remaining children were more variable. This variability, however, is to be expected. The naming account predicts that self-instructional effects will occur *if* the child produces the relevant name on-task. This Skinnerian approach considers outcomes in probabilistic rather than mechanistic terms and recognizes that task performance is always a function of multiple sources of control; particularly in young children, other influences on task performance are likely if the probability of the main independent variable under study, here on-task naming, is not fully controlled. For example, the studies by Horne et al. (2004, 2006, 2007) and Lowe et al. (2002, 2005) show that emergent name-based category sorting of arbitrary stimuli occurred reliably only when the experimenter evoked the child's on-task naming by first pointing to the sample stimulus, and asking ''What's this?'' before indicating the mixed array of stimuli and saying to the child ''Can you give me the others?'' When the children were only asked to look at the sample before sorting the stimuli, many failed to sort the arbitrary comparisons along common name lines, even though they had all previously learned to name the stimuli appropriately, and had passed tact review trials immediately before the sorting test was conducted. In the present study, although the children took part in an intervention that comprised a tact-prompt version of the generalized matching task (with no consequences for correct target matches) they were never prompted to tact the target stimulus in any of the generalized imitation tests employed throughout each experiment: The main independent variable, target naming, was therefore left uncontrolled in the repeated tests that measured emergence of untrained target matching. Although a strong test of the self-instructional effects of naming was not performed in the present experiments, future studies can address this shortcoming.

The Effects of Instructional Context

Another explanation of performance variability is that the self-instructional effects of naming pertain to looking rather than touching behaviors. Naming may therefore generate looking at a target location on the child's and modeler's body, but additional on-task instructions may be required to determine whether the child also touches the body part that he or she names. The instruction ''Do this'' given on each generalized imitation test trial may not have been sufficient in this regard. This instruction is essentially ambiguous: Should the child touch the named body part on the experimenter's body or on her own body? In contrast, the sorting instruction employed in the naming and categorization studies has no such ambiguity: ''Zag'' (sample name produced by child) plus ''Where are the others?'' (experimenter instruction) directs the child's behavior quite clearly from the sample to the comparisons. The possibility that on-task instructions might facilitate the effects of target naming in the imitation test context should be investigated further.

Discrimination Between Target Body Locations

Although the naming interventions resulted in untrained matching of target behaviors, the children did not learn to match all their targets reliably until they took part in direct matching training. Prior to this, their most frequent errors consisted of touching body parts adjacent to the targets. This is surprising given that the novel target responses all terminated on body parts that are visible (see Table 2) and, throughout tact training, the experimenter touched each target body location while she asked the child ''What's this?'' Likewise, during listener training, the experimenter corrected errors by moving the child's arm and hand to enable him or her to touch the location specified by a given listener stimulus, gradually fading this ''putting through'' procedure as the child learned to respond correctly. In both tact and listener training the child was therefore provided tactual and visual stimulation to help him or her discriminate one target location from another. It appears that this bimodal stimulation per se was not sufficient to constrain variability in the children's otherwise untrained matching of the target behaviors. In contrast, the four trained baseline matches required the children to differentiate between their nose, ear, lips or neck—very fine discriminations indeed, and ones that rely exclusively on touch (see Table 2). Nevertheless, these matches were reliable and veridical under intermittent reinforcement throughout the procedures employed in the three experiments and, once established at the

start, never required correction. Children of this age as well as infants are easily able to learn fine discrimination of body part locations, and match them, when the relevant matching relations are established under contingent reinforcement.

Parity and Cross-Body Mapping

One hypothetical constraint on children's matching of target locations modeled on an experimenter's body is that body structure and size is very different when comparing a 3-year-old child with an adult. This might be expected to limit children's discrimination of varying degrees of parity between the modeled behavior and their own responses. However, this study provides good evidence that children's tacts for target locations on their own bodies often generalized without training to the corresponding locations of the adult's body. This outcome suggests that cross-body mapping may not be a serious limitation on young children's target matching (see Baer & Deguchi, 1985).

Direct Matching Training and Maintenance

The impact of direct matching training for all matching relations is demonstrated clearly by the large and significant increases to a mean of 93% in target matching when ''putting through'' and contingent reinforcement were finally employed. This second large change in level clearly supports the findings of our earlier studies on the determinants of matching in infants and young children and reaffirms that repeated presentation of genuinely novel target behaviors in the context of trained and intermittently reinforced matching relations does not of itself result in generalized imitation in infants and young children. That said, direct matching training did not guarantee reliable matching of all the novel targets in the long-term follow-up tests. Target matching averaged 80% over the follow-up data in all three experiments, but for some targets fell to baseline levels under the extinction conditions of these long-term tests. This suggests that intermittent reinforcement, as was provided for the baseline matching relations throughout the procedures in the present and previous studies, may be necessary to maintain even directly trained matching relations. This accords fully with a Skinnerian account of how matching is established and maintained.

Conclusion

Our failure to identify children who learned only listener behavior in the course of the listener training conducted at the outset in Experiment 3 limits our consideration of the findings to the naming account, which is the main theoretical driver of the present study. However, replication of Experiment 3 with a larger number of participants should increase our chances of identifying children who only learn listener behavior (see Horne et al., 2004; 2006) and would enable us to investigate whether this relation on its own results in an increase in novel target matching in young children's performances on generalized imitation tasks, in which case we could reinterpret our findings in terms of simpler behavioral relations. Nevertheless, this first study to investigate the relationship between naming and imitation in very young children found large and significant increases in matching responses following the introduction of the naming interventions. It appears that target naming raises the probability of target matching in most cases to levels that would enable caregivers to fine-tune the relevant matching relations in the day-to-day social environment by providing occasional social reinforcement contingent on a good match to target. This provides support for our hypothesis that naming, and indeed other kinds of verbal self-instruction, may be an important means of accelerating the development of imitation, a repertoire that plays an important role in human learning throughout the lifespan.

REFERENCES

Baer, D. M., & Deguchi, H. (1985). Generalized imitation from a radical-behavioral view-point. In S. Reiss & R. Bootzin (Eds.), *Theoretical issues in behavior therapy* (pp. 179–217). New York: Academic Press.

Baer, D. M., & Sherman, J. A. (1964). Reinforcement control of generalized imitation in young children. *Journal of Experimental Child Psychology, 1*, 37–49, doi:10.1016/0022-0965(64)90005-0

Baer, D. M., Peterson, R. F., & Sherman, J. A. (1967). The development of imitation by reinforcing behavioral similarity to a model. *Journal of the Experimental Analysis of Behavior, 10*, 405–416, doi: 10.1901/jeab.1967.10-405.

Bekkering, H., & Wohlschlager, A. (2002). Action perception and imitation: A tutorial. *Attention and Performance, 19*, 294–314, http://hdl.handle.net/2066/62802

Bekkering, H., Wohlschläger, A., & Gattis, M. (2000). Imitation of gestures in children is goal directed. *The Quarterly Journal of Experimental Psychology, 53*, 153–164, doi: 10.1080/713755872

Brace, N., Kemp, R., & Snelgar, R. (2006). *SPSS for psychologists: A guide to data analysis using SPSS for windows* (Versions 12 and 13) (3rd Ed.). London: Palgrave Macmillan.

Camões-Costa, V., Erjavec, M., & Horne, P. (2010). Comprehension and production of body-part labels in 2- to 3-year-old children. *British Journal of Developmental Psychology*. In Press. doi:10.1348/026151010X523040

Catania, A. C. (1998). *Learning (4th ed.)*. Upper Saddle River, NJ: Prentice Hall.

Erjavec, M., & Horne, P. J. (2008). Determinants of imitation of hand-to-body gestures in 2- and 3-year old children. *Journal of the Experimental Analysis of Behavior, 89*, 183–207, doi:10.1901/jeab.2008.89-183

Erjavec, M., Lovett, V. E., & Horne, P. J. (2009). Do infants show generalized imitation of gestures? II: The effects of skills training and multiple exemplar matching training. *Journal of the Experimental Analysis of Behavior, 91*, 355–376, doi:10.1901/jeab.2009.91-355

Garcia, E., Baer, D. M., & Firestone, I. (1971). The development of generalized imitation within topographically determined boundaries. *Journal of Applied Behavior Analysis, 4*, 101–112, doi:10.1901/jaba.1971.4-101

Gleissner, B., Meltzoff, A. N., & Bekkering, H. (2000). Children's coding of human action: Cognitive factors influencing imitation in 3-year-olds. *Developmental Science, 3*, 405–414, doi: 10.1111/1467-7687.00135

Horne, P. J., & Erjavec, M. (2007). Do infants show generalized imitation of gestures? *Journal of the Experimental Analysis of Behavior, 87*, 63–87, doi:10.1901/jeab.2007.11-06

Horne, P. J., Erjavec, M., & Lovett, V. E. (2009). The effects of modeling, local stimulus enhancement, and affordance demonstration on the production of object-directed actions in 6-month-old infants. *British Journal of Developmental Psychology, 27*, 269–281, doi:10.1348/026151008X297126

Horne, P. J., & Lowe, C. F. (1996). On the origins of naming and other symbolic behavior. *Journal of the Experimental Analysis of Behavior, 65*, 185–241, doi:10.1901/jeab.1996.65-185

Horne, P. J., & Lowe, C. F. (1997). Toward a theory of verbal behavior. *Journal of the Experimental Analysis of Behavior, 68*, 271–296, doi:10.1901/jeab.1997.68-271

Horne, P. J., Hughes, J. C., & Lowe, C. F. (2006). Naming and categorization in young children: IV. Listener behavior training and transfer of function. *Journal of the Experimental Analysis of Behavior, 85*, 247–273, doi:10.1901/jeab.2006.125-04.

Horne, P. J., Lowe, C. F., & Harris, F. D. (2007). Naming and categorization in young children: V. Manual sign training. *Journal of the Experimental Analysis of Behavior, 87*, 367–381, doi:10.1901/jeab.2007.52-06

Horne, P. J., Lowe, C. F., & Randle, V. R. (2004). Naming and categorization in young children: II. Listener behavior training. *Journal of the Experimental Analysis of Behavior, 81*, 267–288, doi: 10.1901/jeab.2004.81-267

Hurley, S., & Chater, N. (Eds.). (2005), Perspectives on Imitation: From neuroscience to social science (Vol. 1). London: MIT Press.

Kymissis, E., & Poulson, C. L. (1994). Generalized imitation in preschool boys. *Journal of Experimental Child Psychology, 58*, 399–404, doi:10.1006/jecp.1994.1041

Lowe, C. F., Horne, P. J., & Hughes, J. C. (2005). Naming and categorization in young children: III. Vocal tact training and transfer of function. *Journal of the Experimental Analysis of Behavior, 83*, 47–65, doi: 10.1901/jeab.2005.31-04

Lowe, C. F., & Horne, P. J. (1996). Reflections on naming and other symbolic behavior. *Journal of the Experimental Analysis of Behavior, 65*, 315–340, doi:10.1901/jeab.1996.65-315

Lowe, C. F., Horne, P. J., Harris, F. D., & Randle, V. R. (2002). Naming and categorization in young children: Vocal tact training. *Journal of the Experimental Analysis of Behavior, 78*, 527–549, doi:10.1901/jeab.2002.78-527

Luiz, D., Barnard, A., Knosen, N., Kotras, N., Horrocks, S., McAlinden, P., Challis, D., & O'Connell, R. (2006). *MDS-ER 2–8 – Griffiths Mental Developmental Scales – Extended Revised: 2 to 8 years*. Oxford: Hogrefe.

Peterson, R. F. (1968). Some experiments on the organization of a class of imitative behaviors. *Journal of Applied Behavior Analysis, 1*, 225–235, doi:10.1901/jaba.1968.1-225

Poulson, C. L., & Kymissis, E. (1988). Generalized imitation in infants. *Journal of Experimental Child Psychology, 46*, 324–336, doi:10.1016/0022-0965(88)90064-1

Poulson, C. L., Kymissis, E., Reeve, K. F., Andreatos, M., & Reeve, L. (1991). Generalized vocal imitation in infants. *Journal of Experimental Child Psychology, 51*, 267–279, doi:10.1016/0022-0965(91)90036-R

Poulson, C. L., Kyparissos, N., Andreatos, M., Kymissis, E., & Parnes, M. (2002). Generalized imitation within three response classes in typically developing infants. *Journal of Experimental Child Psychology, 81*, 341–357, doi:10.1006/jecp.2002.2661

Sherman, J. A., Clark, H. B., & Kelly, K. K. (1977). Imitative behavior in preschool children: The effects of reinforcement, instructions, and response similarity. In B. C. Etzel, J. M. LeBlanc, & D. M. Baer (Eds.), *New developments in behavioral research: Theory, method, and application. In honor of Sidney W. Bijou* (pp. 503–529). Hillsdale, NJ: Erlbaum.

Skinner, B. F. (1953). *Science and Human Behavior*. New York: Macmillan.

Steinman. (1970). The social control of generalized imitation. *Journal of Applied Behavior Analysis, 3*, 159–167, doi:10.1901/jaba.1970.3–159

Waxler, C. Z., & Yarrow, M. R. (1970). Factors influencing imitative learning in preschool children. *Journal of Experimental Child Psychology, 9*, 115–130, doi:10.1016/0022-0965(70)90104-9

Zentall, T. R. (2006). Imitation: Definitions, evidence, and mechanisms. *Animal Cognition, 9*, 335–353, doi:10.1007/s10071-006-0039-2

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APPENDIX

Children's incorrect touches in response to matching trials (ordered by percentage from highest to lowest) of each target gesture across all Experiments.

Target gestures	Children's incorrect touches (ordered by percentage from highest to lowest)
T1 Temple	55% (Anna) to eyebrow, 43% (Mila) to wrist, 25% (Anna) and 16% (Mila) to ear, and 24% (Mila) to the side of the head.
T2 Bridge of foot	87% (Jack), 86% (Carl), 85% (Fex), 20% (Emma), and 17% (Gina) to the outer side of the foot, 51% (Emma) and 34% (Gina) to the sole of the foot, 18% (Emma) to toes, 14% (Gina) to ankle, and 11% (Gina) to the top of the foot.
T3 Armpit	38% (Fin) and 26% (Mol) to upper arm, 38% (Carl) to the back of the head, 33% (Fin) to lower arm, 32% (Mol) to tummy, 25% (Carl) to elbow, 23% (Mol) to chest, and 21% (Fin) to the crook of the arm.
T4 Thigh	99% (Mila), 79% (Anna), and 37% (Jack) to knee, 58% (Jack) and 19% (Anna) to shin.
T5 Crook of arm	53% (Mol) to upper arm, 49% (Emma) and 15% (Mol) to lower arm, 19% (Emma) to the back of the hand, and 16% (Emma) and 13% (Mol) to wrist.
T6 Crown	47% (Emma) to forehead, and 13% (Emma) to the side of the head.
T7 Ankle	77% (Gina) and 75% (Fin) to the arch of the foot, 43% (Anna) to heel, 14% (Anna) to the sole of the foot, and 13% (Fin) to the top of the foot.
T8 Wrist	93% (Fin), 88% (Emma), 79% (Mol), 78% (Anna), 70% (Gina), 67% (Carl), and 42% (Fex) to the back of the hand, 53% (Fex) to pulse, 25% (Carl) and 24% (Gina) to lower arm, and 20% (Anna) and 17% (Mol) to fingers.
T9 Upper arm	61% (Jack), 53% (Carl), 42% (Fin), and 24% (Mol) to lower arm, 39% (Mol) to wrist, 33% (Fin), 26% (Jack), 20% (Carl), and 12% (Mol) to the crook of the arm, 13% (Carl) to ear, 11% (Fin) to elbow, and 11% (Fin) to the back of the hand.
T10 Lower arm	53% (Gina) to wrist, and 22% (Gina) to the back of the hand.
T11 Shin	64% (Mila) to knee, and 23% (Mila) to thigh.
T12 Calf	78% (Fex) to the back of the knee, and 15% (Fex) to the back of the thigh.
T13 Thumb	72% (Fex) to the index finger, and 22% (Fex) to fingers.
T14 Hip	76% (Mila) and 26% (Jack) to waist, 35% (Jack) to thigh, 16% (Mila) to ribs, and 12% (Jack) to knee.